Thorny issues in perception in action

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Introduction

The present thesis was set out to gain further insight in the roles of visual information in movement control (i.e., vision for action) and perception (i.e., vision for perception) and how they complement each other in the course of an action. The point of departure for the studies presented in this thesis was Goodale and Milner's (1992) parallel view of action and perception. These authors argued that two separate, neuro-anatomically and functionally visual systems exist that mediate the exploitation of visual information for perception and action. The dorsal visual stream, which projects to the posterior parietal cortex, supports the online visual control of movement (i.e., vision for action), coding objects in relation to the actor in absolute metrics, as egocentric information. The ventral visual stream, which projects to the inferotemporal cortex, is involved in the visual perception of the world around us (i.e., vision for perception), coding objects and their properties in relation to other objects in relative metrics, as allocentric information. Chapters 2 and 3 addressed the explanatory value of this parallel view of action and perception and contrasted it with serial views, in which vision is used to create a general perceptual representation that in turn is used to guide action. The results were found to be more consistent with Milner and Goodale's parallel view of action and perception, and hence, the remaining Chapters investigated how vision for action and vision for perception work together in order to produce purposive behavior, an issue which had not received much scrutiny. Chapters 4 and 5 further delineated vision for perception contributions in the course of action. Another issue that has been relatively overlooked, since Goodale and Milner's proposal, is that the functional demands of movement control and perception also impose different constraints on information detection. The final experimental chapter (Chapter 6) therefore investigated how information detection for action and perception differs. As an epilogue to the thesis, this Chapter provides a concise summary of the main findings of the reported studies, followed by the general conclusions.

Summary of the main findings

Chapter 2 addressed whether participants who intend to intercept a moving object that is temporally occluded from view continue to 'track' the object or make a predictive gaze shift to the location where the object is intercepted.

Participants were presented with moving objects that approached from the right side in the frontoparallel plane. In one condition, the object was visible throughout its trajectory, whereas in the second condition the object was made invisible for the final part of its trajectory. The participants caught the object when it passed in front of them. Participants directed their gaze to the moving bar in both viewing conditions, which was indicated by tight coupling of gaze to the moving bar and a low number of gaze shifts in the direction of the interception point, even when the object was occluded. In other words, participants 'tracked' the object throughout its entire trajectory also when the object was occluded from view. A remarkable finding was that, unlike in perceptual motion prediction studies, participants acted as if they underestimated the time the bar would arrive at the point of interception when occluded. It was argued that this discrepancy may be accounted for by the differential involvement of vision for action and vision for perception.

Chapter 3 therefore made a more direct comparison between the role of visual information in action and perception. It explicitly compared the views that action and perception are dissociated (parallel view) or that perception enslaves action (serial view). This was done by assessing whether systematic distortions in perceptual judgments lead to similar inaccuracies in catching. In the perception experiment, participants manually aligned the orientation of a bar to the orientation of a reference bar placed at different distances in the frontoparallel plane. In the action experiment participants caught differently oriented moving bars, which either remained visible during the entire trajectory or were occluded 0.5 m before the interception point. The perception experiment showed systematic orientation errors, in particular for the oblique bar orientations. These errors increased in magnitude with an increase in the distance of the reference bar. The action experiment also revealed orientation errors. However, these orientations were different from those found in the perception experiment. These findings were interpreted to be more in line with the view that vision for perception and action are dissociated rather than that perception enslaves action.

The study presented in Chapter 4 examined the contribution of vision for perception in action. To this end, the influence of allocentric sources of information on the components that constitute an action (i.e., the selection of an appropriate mode of action, and the pre-planning and online control of movement kinematics) were assessed. The assumption was that the use of allocentric sources of information point toward contributions of vision for perception. Participants grasped and made perceptual estimates of the length of shafts that were embedded in a Müller-Lyer configuration. Depending on the length of the shaft, participants had to select either a one- or two-handed response. It was found that the Müller-Lyer configuration affected the choice between using one- or two-handed responses when grasping the shaft to a similar degree as the perceptual estimates, thereby indicating the involvement of vision for perception in the selection of an appropriate mode of action. In contrast, the Müller-Lyer configurations had only a minor effect on movement kinematics during grasping, suggesting the use of egocentric information mediated by vision for action. It was concluded that the division of labor between vision for action and vision for perception is not absolute; vision for perception contributes to the selection of an action mode.

Chapter 5 demonstrated a further role of vision for perception in action. The study addressed the role of vision for perception in determining the location of a target in a far-aiming task. In the same vein as in Chapter 4, the use of allocentric information was assessed in a task in which participants slid a disk toward a distant target embedded in Judd configurations. A clear illusory bias in sliding was observed, which was of similar magnitude as the bias in the perception of target location. This indicated the use of allocentric information in determining target location in far-aiming. It was argued that vision for perception sets the boundary constraints for action and that within these constraints vision for action autonomously controls movement execution.

Finally, Chapter 6 sought to obtain insight in whether the functional demands of vision for perception and vision for action impose different constraints on information detection in addition to the traditionally emphasized differences in the processing of information. Participants grasped and made perceptual estimates of shafts of various lengths that were embedded in a Müller-Lyer illusion (i.e., as in Chapter 4). The participants' gaze patterns were measured to investigate task-specific differences in information detection. The illusion significantly affected the manual estimates but not the hand aperture during grasping. In line with these behavioral findings, significant differences in gaze patterns were revealed between the two tasks. Participants spent more time looking at areas that contain egocentric information when grasping as compared to making a manual length estimate. In addition, participants made more gaze shifts when making the manual length estimate, enabling the pick-up of allocentric information. These results support the contention that the functional distinction between the dorsal and ventral systems is not limited to the processing of information but also encompasses the detection of information.

Concluding remarks

This thesis investigated the relationship between vision for action and vision for perception and how they complement each other in the course of an action. The results of the present thesis favored a parallel view of action and perception (i.e., a functional dissociation between vision for perception and vision for action) as proposed by Goodale and Milner (1992). Importantly, however, the thesis further delineates and extends this parallel view. It demonstrates 1) how vision for perception and vision for action interact in the course of action, and 2) that the functional distinction also encompasses information detection. These further specifications to Goodale and Milner's model are illustrated in Figure 7.1 (cf. Figures 1.1 and 1.2).

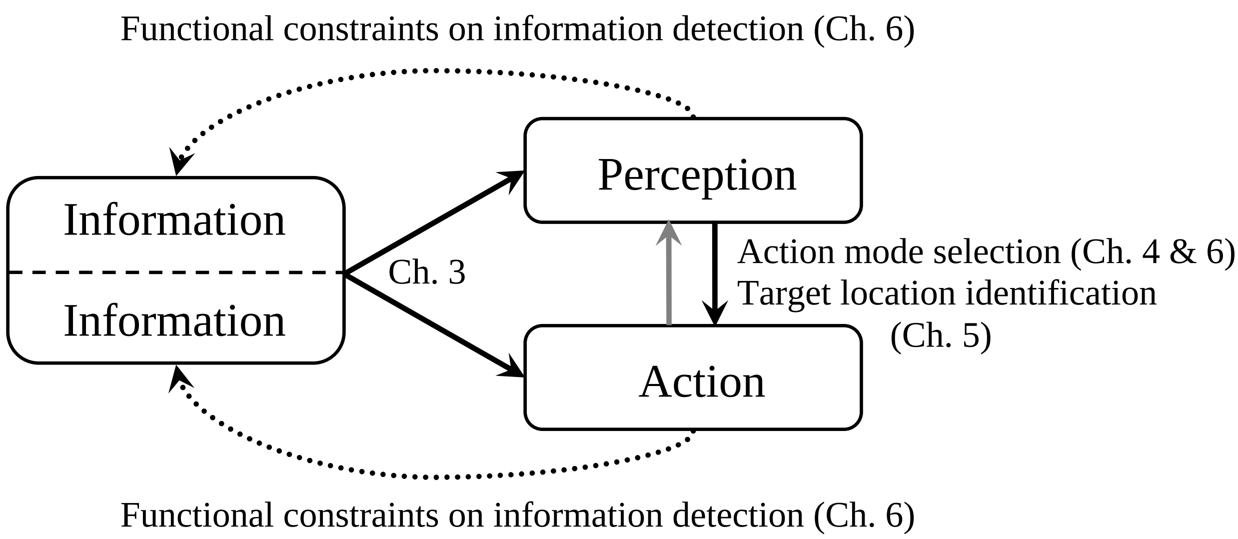

Figure 7.1. Parallel view of perception and action. Arrows indicate studied relationships between perception, action and information. See text for further explanation.

First, the thesis provides evidence of vision for perception contributions in the course of action. It demonstrates contributions of vision for perception in action mode selection and the identification of the location of a target (see downward arrow between perception and action in Figure 7.1). It also appeared that the role of vision for perception in the control of movement was marginal at best. In sum, it is concluded that vision for perception and vision for action serve distinct yet complementary functions in the course of action. This interaction was interpreted as vision for perception setting the boundary constraints for action, rather than prescribing the movement kinematics. Within the constraints set by vision for perception, vision for action autonomously controls movement execution. Yet, future research is necessary to substantiate these conjectures.

Second, the thesis provides evidence that the functional distinction between vision for perception and vision for action is not restricted to the processing or encoding of visual information in different frames of references, but that it also comprises the process of information detection (see the dashed lines between perception, action and information in Figure 7.1). One important issue for further consideration is whether these constraints on information detection can be linked in more detail with the complementary roles of vision for perception and vision for action in the course of action. In addition, it would be important to further scrutinize to what degree gaze behavior actually determines the information used. For instance, would movement control become more susceptible to illusion when participants are forced to gaze toward allocentric sources of information?